column of water would indicate directly the intensity of the radiation of the sun in calories if the ice did not also partly melt in consequence of the surrounding warm air. In order to eliminate this influence, the progress of the column of water must be observed before and after the actual experiment, and during these observations the sun's rays must be shut out from the apparatus by a screen. The difference of the readings with and without the sun's rays will then indicate the density of the latter. But this method has a drawback. It was found that with experiments which were made in quick succession, when the apparatus was exposed to the sun's rays, that the first results were always a little larger than the following ones, and that only after some time had elapsed did the results show a constant value. The reason of this is doubtless the formation of a stagnant layer of water in the apparatus below the blackened plate, and this layer must first reach a stationary position before anything like regularity is obtained in the results.

With regard to the general results of these experiments, which were made by Messrs. Röntgen and Exner on the platform of Strassburg Cathedral, the absolute values of the intensity of the radiation of the sun are considerably larger than those found by Pouillet. If Pouillet's values are reduced to the same measures and units, which form the basis of the values obtained by Röntgen and Exner, we find, for instance, for the month of June and the sun's elevation 12h. the value 1·140, while the latter observers still obtained 1·226 for an elevation of 12h. 15m. Further, we must remark that the values obtained by Röntgen and Exner are decidedly too small (the observations record the progress of the column of water after the stationary condition of the stagnant layer of water), and that according to a rough guess they should be at least 20 per cent. to 25 per cent. larger; thus it is certain that Pouillet's values must be looked upon as *considerably too small*.

*FERTILISATION OF FLOWERS BY INSECTS**

XI.

Adaptation of Flowers to Lepidoptera—Hesperis tristis.

LEPIDOPTERA are distinguished among all insects that visit flowers by their slender proboscis. Hence, in order to make their honey exclusively accessible to these insects, flowers have only to narrow the entrance to their nectaries to such a degree that no other proboscis but that of Lepidopterous insects is able to enter. This adaptation to butterflies by narrowing the entrance of the nectary in different families of plants has been

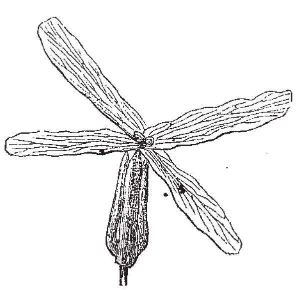

FIG. 65.—Flower of *Hesperis tristis* (natural size).

arrived at in very different ways. In flowers with a tubular corolla (*Primula villosa, Daphne striata*, NATURE, vol. xi. p. 110, Figs. 43-47) the corolla-tube has narrowed; in flowers with a honey-secreting spur (*Gymnadenia, Nigritella*, NATURE, vol. xi. p. 170, Figs. 58-62) the entrance of the spur has been constricted; in the labiate flowers of *Rhinanthus alpinus* (NATURE, vol. xi. p. 111, Figs. 51-56) the large entrance of the flower is blocked up by the margins of the upper lip lying close together, and only a small opening in its rostrate projection has been left open; in the quite open flowers of *Lilium Martagon* (NATURE, vol. xii. p. 50) the honey-secreting furrow at the base of the sepals and petals has been converted into

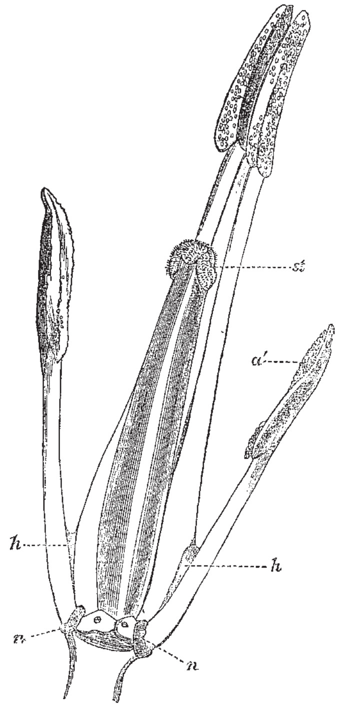

FIG. 66.

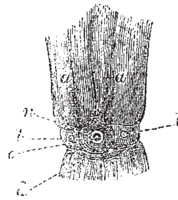

FIG. 67.

FIG. 66.—The same after the sepals, the petals, and two of the four longer anthers have been removed. *n*, nectary; *h*, honey; *a'*, shorter anther; *st*, stigma.

FIG. 67.—Situation of the nectary. *a a*, longer filaments; *o*, point of insertion of one of the shorter filaments; *b b*, points of insertion of the two adjacent petals; *d*, insertion of the adjacent sepal; *n*, nectary.

a narrow channel by a coating of glandular hairs. *Hesperis tristis*, belonging to the family of Cruciferæ, which are generally visited for honey by Apidæ, Syrphidæ, Muscidæ, and various other insects, has excluded from its honey all visitors except Lepidoptera, by simply lengthening its sepals and the basal portion of its petals and laying them close together. The sepals, indeed, as is shown by Fig.

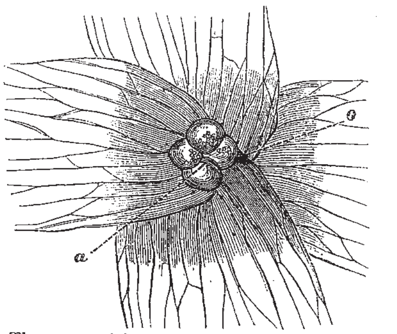

FIG. 68.—The centre of the flower at its first period seen from above. *a*, longer anthers; *o*, openings.

65, are elongated to 11-15 mm., and whilst diverging and presenting open slits in their basal portion, are convergent and connate towards their tips. By this coalescence of the sepals the entrance of the flower is so constricted as to be almost completely filled up by the four longer anthers (*a*, Figs. 68, 69). At first, when the

* Continued from p. 50.

flower has just opened, only a single very small opening is commonly left free (*o*, Fig. 68); somewhat later, when the longer anthers have advanced a little further, two small openings are frequently obvious (*o o*, Fig. 69), by which Lepidoptera can insert their proboscis. The exclusion, however, of all other insects from the honey would be useless or even fatal to this, as well as to the above mentioned flowers, unless by particular contrivances, (1) increased frequency of the visits of Lepidoptera,

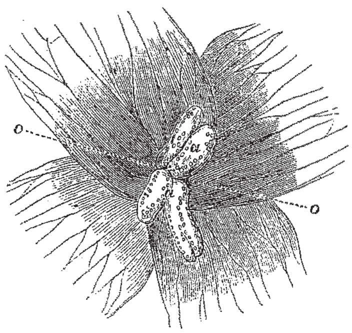

FIG. 69.—The same, at a somewhat later period.

and (2) certain cross-fertilisation by them were effected. *Hesperis tristis*, by the very inconspicuous colour of its flowers, which are yellow reticulated with purplish streaks, by opening them in the afternoon, and by having no smell in the daytime whilst very fragrant towards the evening, proves to be adapted exclusively to crepuscular and nocturnal Lepidoptera, which, attracted from afar by the sweet odour, are induced to pay frequent visits. The base of each of the two shorter filaments is surrounded by a greenish swelling (*n*, Figs. 66, 67), which secretes on its inside honey so copiously that it rises in the interstice between the shorter and the two adjacent longer filaments. Cross-fertilisation by the visits of moths is secured in the following manner. From the one or two small openings (*o*, Figs. 68, 69) the proboscis of the moth is guided downwards by the longer filaments as in a channel, first along one side of the stigma (*st*, Fig. 66), which has bent downwards on both sides just into the way of the proboscis, then

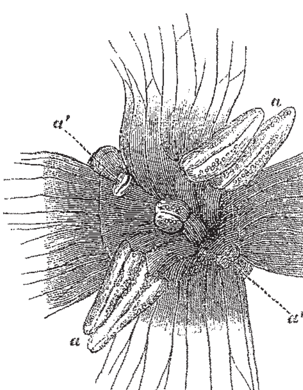

FIG. 70.—The same in its last state.
(Figs. 66–70 are seven times magnified.)

along the shorter anther (*a'*, Fig. 66), which from the other side has turned its pollen-covered front likewise exactly into the way of the proboscis, until at last it reaches the honey (*h*, Fig. 66); the proboscis afterwards wetted with honey at its tip, when retracted, first touches again the anther *a'* with one side, which is thus charged with pollen, then with the other side the stigma, which thus escapes fertilisation with its own pollen, and when in the next visited flower the tip of the proboscis with its pollen-charged side touches the stigma, cross-fertilisation is effected.

My daughter Agnes, perseveringly watching *Hesperis tristis* during several mild evenings in the month of May, has succeeded in observing and catching the following fertilisers of it:—(1) *Plusia gamma*, frequently (length of the proboscis 16-18 mm.); (2) *Hadena sp.* (11 mm.); (3) *Dianthœcia conspersa*, W.V., twice (13 mm.); (4) *Iodis lactearia*, L.; (5) *Botys forficalis*, L., three times.

But although in calm and warm evenings, as is proved by these observations, cross-fertilisation may be sufficiently effected; yet in unfavourable weather all flowers of many individuals develop and fade without experiencing any visit of fertilisers. In this case, nevertheless, almost every ovary develops and brings to maturity its seed-vessels, self-fertilisation being regularly effected by the pistil growing and the stigma coming into contact with pollen-grains of the four longer anthers.

Thus, in these flowers the four longer anthers have apparently no other function in the first period of flowering but to exclude incompetent visitors from the honey, by stopping the entrance of the flower, and, by the direction of their filaments, to keep the proboscis of the fertilisers in the right direction, whilst in a later period, in case visits of moths have been wanting, they regularly effect self-fertilisation. The two shorter anthers, on the contrary, are exclusively adapted to cross-fertilisation by visiting moths.

Lippstadt HERMANN MÜLLER

JOSEPH WINLOCK

THE following details concerning the late Prof. Winlock, whose death we announced last week, we take from the New York *Nation*:—

Prof. Joseph Winlock, Director of the Observatory of Harvard College, died suddenly after a brief illness last Friday morning, June 11, at the age of forty-nine. One of the foremost of American astronomers, whose honourable career in science began thirty years ago, who has filled with great credit several important positions of scientific labour and trust, is thus cut off in the midst of a life whose usefulness cannot be estimated by ordinary standards. Well known and highly estimated by all active collaborators in astronomy both at home and abroad, he was never so well known to others or to the public as his important services deserved. This was chiefly on account of a modest shrinking from any candidacy for honours, amounting almost to an aversion from them, and an indifference to an uncritical or merely popular reputation. Immediately upon graduating from Shelby College, Kentucky, in 1845, he was appointed Professor of Mathematics and Astronomy in that College, where he remained until 1852, when he removed to Cambridge, Mass., and took part in the computations of the *American Ephemeris and Nautical Almanac*, then under the superintendence of Admiral C. H. Davis. In 1857 he was appointed Professor of Mathematics of the United States Navy, and in that capacity served in succession as Assistant at the Naval Observatory at Washington, as Superintendent of the *Nautical Almanac*, and as Director of the Mathematical Department of the Naval Academy at Annapolis, Md. On the breaking out of the war, in 1861, he was a second time made Superintendent of the *Nautical Almanac*. His next service to astronomy was in the position of Director of the Observatory at Harvard College, and Phillips Professor of Astronomy, to which he was appointed in 1865—a position already made highly honourable by the labours of his predecessors, the distinguished astronomers, Professors W. C. Bond and G. P. Bond. He has also served at the same time as Professor of Geodesy in the Mining School of Harvard College. Only a few months ago, Mr. Bristow appointed him the chairman of the Congressional Commission for